CONCAWE Review

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CONCAWE *is the oil companies' European organization for environment, health and safety. The emphasis of its work lies on technical and economic studies relevant to oil refining, distribution and marketing in Europe.*

CONCAWE *was established in 1963 in The Hague, and in 1990 its Secretariat was moved to Brussels.*

concawe

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Foreword

Dear Reader,

Agreement has now been reached between the Environment Council and the European Parliament on the 2000/2005 emission standards for passenger cars and light commercial vehicles and the related fuel quality requirements. In a press release Mrs Bjerregaard, the Commissioner responsible for the EU environmental legislation, acknowledged that 'the cooperation of the industry preparing the required technical data on which the Commission's proposals were based, has been crucial to the final result.' CONCAWE appreciates this statement since its experts have contributed their share of technical information to facilitate the preparation of a scientifically justified Commission proposal based on environmental needs and cost-effective abatement measures.

However, CONCAWE considers that the 'final result', namely the Conciliation agreement between the Council and the European Parliament deviates from the principles originally agreed between them. The fixing of the 2005 fuel quality requirements now is premature and not based on the technical and scientific facts developed so far during the Auto/Oil programme. The conversion of the 2005 'indicative' 50 ppm sulphur limit for gasoline and diesel fuel and the 35 per cent aromatics limit for gasoline into mandatory limits was supposed to be evaluated and confirmed during the ongoing Auto/Oil Programme II.

The redirection of vehicle emissions legislation towards a best available technology approach leaves CONCAWE with the fundamental question: how can we convince decision makers of the value of a technical/scientific approach when dealing with complex environmental issues to arrive at solutions that are optimal for Europe? Nevertheless, CONCAWE will continue to promote its view of addressing environmental issues in the overall EU context and assigning financial resources to individual issues with the objective of minimizing the sum of risks to society. Overspending society's money on one popular political issue (like extreme fuel quality requirements) without achieving significant additional benefits will withdraw funds from solving other problems exhibiting a higher risk to mankind. CONCAWE's detailed considerations in this area were addressed in the risk characterization/management article in the April 1998 *Review*.

In this context I want to draw your attention to this *Review's* article on page 5 dealing with the precautionary principle. CONCAWE is a technical/scientific organization and its expertise lies in these areas rather than with the legal aspects of this issue. However, it was felt that CONCAWE should present its views on the practical significance of this widely discussed statement of policy vis-à-vis the risk based approach of enacting environmental legislation

The Precautionary Principle as such has made its entry into various international agreements, declarations and conventions, is being reflected in national legislation and is also included in Article 130r of the EU Treaty. Since this latter Article refers also to the need to take into account cost-benefit aspects of EU environmental legislation, CONCAWE decided to address the challenges of this dual approach.

Jochen Brandt
Secretary-General, CONCAWE

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Current CONCAWE activities

CONCAWE's continued aim is to provide reliable technical and economical data on oil-related environment, health and safety topics.

The call on CONCAWE to contribute to the large number of initiatives in Europe remains high, and many of the issues span the spectrum of scientific and technical fields of expertise that CONCAWE is involved in.

AIR QUALITY

The various air quality initiatives where CONCAWE is involved include: follow-up to the first Auto/Oil programme; and development of Air Quality Framework Directive daughter directives, EU Acidification and Ozone Strategy, and guidance and reference documents in relation to the Integrated Pollution Prevention and Control Directive. These activities span subjects as diverse as emissions controls from both mobile and stationary sources, health aspects of pollutants, cost assessments of the controls under evaluation and methods to evaluate the environmental benefits of potential legislation.

AUTOMOTIVE EMISSIONS

Activities are related to the Auto/Oil (after conciliation entering the redefined second phase) and Air Quality Framework Directive, and encompass investigations of particulate exhaust emissions from vehicles and a review of information on polycyclic aromatic hydrocarbons (PAH) in exhaust emissions from vehicles. Other activities include automotive fuels quality monitoring, updating of the CONCAWE report on motor vehicle emissions regulations and fuel specifications, and an ongoing review of engine after-treatment technology and fuel quality implications.

HEALTH

CONCAWE has initiated a programme related to occupational noise. Two activities have begun. One is to update the previously published CONCAWE occupational noise exposure survey. The second activity is to assess the incidence of noise-induced hearing loss in the petroleum industry and compare this with the incidence 10 years ago. Reports are being finalized on occupational hygiene auditing and the scientific basis for an air quality standard for nickel.

PETROLEUM PRODUCTS

Report No. 98/54 updating the CONCAWE recommendations on the classification and labelling of petroleum substances has been published and a digest of the information for individual substances is also available as a Microsoft® Access searchable database. This can be obtained from the CONCAWE Website. A companion report summarizing all the environmental data on petroleum substances relating to classification is due for publication early in 1999. Exposure data for crude oil have been collated in Report No. 98/52 and a similar report for kerosines/jet fuels is due to be published by the end of 1998.

The exercise in updating petroleum substance group HEDSETs has been completed and there has been overwhelming support for the CONCAWE initiative in assuming responsibility for the scientific data associated with these substances.

SAFETY

CONCAWE is assisting the Commission in assessing the implications that the classification of some common petroleum substances for environmental hazard will have under the COMAH (Seveso II) Directive. The aim is to ensure that appropriate controls are applied to petroleum storage installations without posing unnecessary administrative burdens on either operators or the regulatory authorities. It is also producing guidance for Member Companies on the implementation of the Directive.

WATER QUALITY AND WASTE

CONCAWE has recently carried out its regular survey of refinery effluents and the report will be published shortly. This time, it also collected the data on behalf of the Oslo and Paris Commissions for all those refineries whose effluent eventually enters the North Sea and Atlantic Ocean. It is also studying the Water Quality Framework Directive and the process by which substances hazardous to the aquatic environment will be prioritized.

PIPELINES

The overview report of the 25 years of CONCAWE pipeline statistics has been published along with an update of the 1987 report on pipeline integrity management. CONCAWE (along with other pipeline federations) is assisting DG-XI in its development of a new Directive on Major Accident Hazards from Pipelines.

The 'Precautionary Principle'

Application in a multi-issue world.

INTRODUCTION

The *Precautionary Principle* has become very much a part of the vocabulary of the general environmental scene today. It has found its way into various international declarations and conventions, is being reflected in national legislation and is also included in Article 130r of the EU Treaty[1]. Often appealed to as the basis for 'we must act now', 'we must do more' or 'we must go further', it is viewed by many as a potentially powerful argument for the environmental agenda. In Industry, this perception brings with it a real concern that its application threatens another key principle, viz. that environmental legislation should be based on sound science and cost-effectiveness.

Are such concerns valid and if so why? Does the problem lie with the principle *per se* or with its application? The aim of this brief article is to address these key questions.

ITS ROOTS

We begin by looking at the *Precautionary Principle* itself. Here we already encounter some difficulties because of the different forms in which it appears. Having said this, the main difference is that in some cases reference to economic considerations are made but in others there are no such references. Although there are various versions, perhaps the most quoted and widely accepted version is found as 'Principle 15' in Annex B of the Rio Declaration on Environment and Development:

'In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.'

It is helpful to put this in the context of the overall declaration. For example, at the outset of the declaration it is clear that it takes a holistic view of man and his environment. So the declaration includes a statement of the essential prerequisite of eradicating poverty as the route to a 'sustainable world'; it also includes a recognition of the potential for inappropriate and unwarranted economic and social costs if overly stringent ambitions are set, particularly in developing countries. In other words, there is recognition of the importance of economic factors in the process of designing appropriate environmental responses. There is also recognition of the need to consider priorities. This not only involves asking 'What first?' but forces the question 'At what point do we stop spending societal resources on this issue, with its diminishing societal benefit, and start spending on a now more pressing issue?' In other words it moves us away from a single-issue to a multi-issue focus.

This backdrop is very helpful in understanding the form of words in 'Principle 15'. For example 'according to their capabilities' recognizes the need to respect the limits imposed by 'affordability'.

[1] *Treaty on European Union, Maastricht*

'Lack of full scientific certainty' does not imply a jettisoning of the need to bring the best understanding of science to an issue but rather recognizes that serious issues cannot always wait for a full understanding. Finally, the inclusion of 'cost-effective measures' reflects the concern to be precautionary with societal resources to assure a healthy economy.

A PROBLEM WITH PRINCIPLE OR PRACTICE?

So to come to the questions posed at the outset. The Rio version of the *Precautionary Principle* is clearly founded on a recognition that wise stewardship of economic resources must accompany its application in a given situation. Although it is concerned with ensuring that scientific uncertainty is not an absolute impediment to appropriate/timely action, it clearly implies a continued and important role for the best understanding science can provide. Finally it affirms the need to seek cost-effective solutions. As such this contains the essential main elements of what the oil industry has called the rational approach, i.e. response strategies should be based on using 'best science' to understand the problem/determine the environmental objective and that the most cost-effective solution should be determined to deliver that objective. The problem then does not seem to be with this principle per se but with its application and its variants.

The first concern is the elimination or marginalization of any economic and social considerations in applying the principle. Such a stance is often perceived as the 'environmental high ground', but does this stand up to a close examination? In the light of the many problems facing society, how is the legislator to approach the task of ensuring that moneys are spent in a way that maximizes overall benefit to society (health and the environment)? (A key concern to those who signed the Rio Declaration.) The process of environmental legislation is so often a 'single issue' process; it is therefore vital that the relationship between societal expenditure and societal benefit/disbenefit is properly understood. Otherwise the legislator cannot be in a position to judge wisely whether or not to act or at what point it would be better to stop spending on one issue and address another. Any action, even if performed to protect the environment, will itself have some effect on the environment. If the *Precautionary Principle* is applied on the basis of preconceptions without as full as possible a scientific analysis, then greater problems may occur. An example of the problems that can arise from focusing on a single issue is the action taken as a result of concerns over the potential carcinogenicity of high chlorine levels in drinking water. Reducing the levels in a developing country resulted in a significant increase in the number of deaths due to waterborne diseases.

One response to the concern to ensure that environmental expenditure results in an overall societal benefit has been a growing use of studies that attempt to place a monetary valuation on the benefits. If the valuation of benefits equal or exceed the cost of delivering them, 'it must be justified'. Apart from the enormous uncertainties in this process, it fails to address the key question of whether a much greater benefit would derive from spending this money on a different problem.

The second concern relates to the use of the *Precautionary Principle* on issues where the consequence of waiting for a fuller scientific understanding really cannot be said to represent 'a threat of serious or irreversible damage'.

A current example of this is the European Acidification Strategy. Here we have an initiative that makes appeal to the *Precautionary Principle* and is designed to make further progress towards the ultimate ambition of achieving 'no-exceedance' of critical loads in the European Union. Seen in isolation this seems to be an appropriate priority for the EU given the long-term changes that have resulted from acidifying emissions. However, there have already been significant international commitments in response to this problem. In particular the 2nd UN-ECE Sulphur Protocol is designed to deliver substantial reductions in sulphur dioxide emissions over the next decade, particularly in Northern European countries like Germany (see Figure 1). As a consequence sulphur deposition levels are anticipated to fall by factors of five or more in the critical areas of Europe compared to peak levels in 1980. Together with substantial NO_x reduction measures in transport and emission reductions form other sources, this will result in significant progress towards achieving the critical loads. However, exceedances are anticipated to remain in limited areas. This conclusion forms the justification for 'more action' via the Acidification Strategy. Is such action warranted now? Is the application of the *Precautionary Principle* appropriate in this case? To answer these questions we need to focus first on the concept of *critical loads* and then on the economic implications of further action.

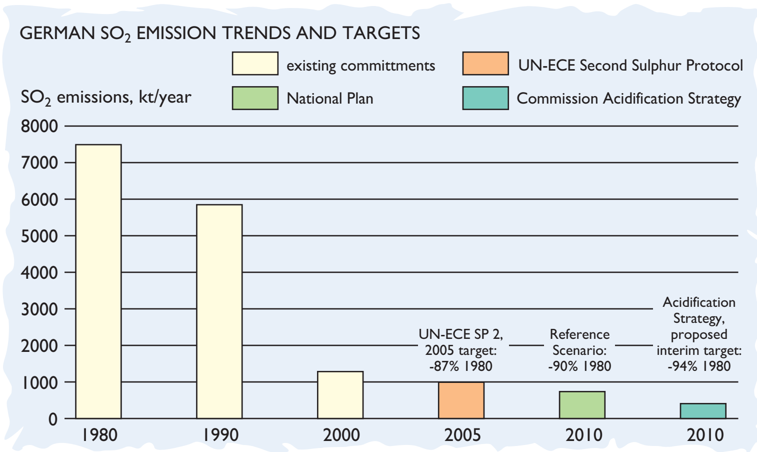


Figure 1
Existing international commitments will result in significant progress towards achieving the critical loads.

Besides being subject to significant scientific uncertainty, the critical load concept is, by its very nature, a static concept. It does not include any aspect of the dynamics of damage or recovery. It is essentially interpreted as an 'OK' or 'Not OK' concept. No attempt is made to quantify the difference in the potential for damage whether at ten per cent above the critical load or at ten times the critical load! This must be seen against the backdrop of a growing body of evidence to suggest that the environment is already responding positively to measures taken to reduce acidification. This can only accelerate as already mandated measures result in further substantial reductions through the next decade.

The Acidification Strategy highlights the 'significant' remaining areas where critical loads will continue to be exceeded without further reductions. However, even the application of maximum feasible reductions offers little further compliance with critical loads in 2010 beyond that offered by already mandated measures. On the other hand, the economic consequences of such reductions are extreme (See Figure 2). As well as placing a significant and widely varying burden on national economies, this would have profound implications for the viability of certain industries e.g., coal. In the light of this, it would seem that a more prudent response would be to monitor how the environment responds to already agreed substantial measures before defining/implementing further measures. Ironically this seems to be much more in harmony with the Rio Declaration!

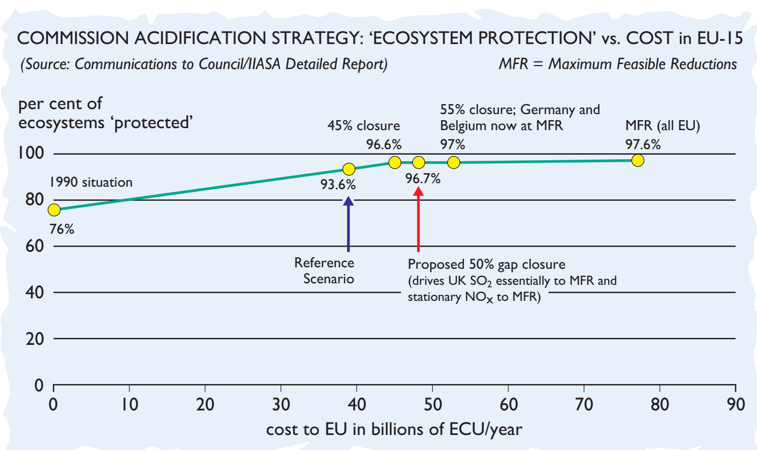


Figure 2
The application of maximum feasible reductions offers little further compliance than already mandated measures.

In conclusion then, the *Precautionary Principle per se* is not the problem (at least the form of words in the Rio Declaration); rather, the problem is in its application. It implies a continued role for 'best science'. It sees a central role for the consideration of economic and social factors including issues like affordability and cost-effective solutions. It recognizes the multiplicity of issues facing society. If these factors were properly accounted for in applying the principle with full transparency, it is more likely to enjoy overall industry acceptance.

Acidification strategy sensitivity analysis

Flexibility leads to similar overall environmental protection at lower cost.

INTRODUCTION

In mid 1997, the European Commission published its strategy to combat adverse environmental effects resulting from the deposition of acidifying pollutants. The ultimate target was to achieve zero exceedance of critical loads for acidification (*CONCAWE Review* Volume 7, Number 1). As this will be unachievable within the foreseeable future, the Commission's proposals sought a least cost solution to achieving a 50 per cent gap closure by 2010 towards this ultimate target. At the time the proposals were published it was estimated that the proposed Acidification Strategy would cost the EU-15 an extra ECU 7 billion per annum, in addition to the ECU 40 billion per annum to implement existing emission reduction commitments for SO_x, NO_x and NH_3.

The 50 per cent gap closure target was chosen as it represented the 'knee' on the overall EU cost curve—the argument being that beyond that point, the cost-effectiveness of measures declines rapidly. However, the choice of this ambition level did not specifically include an examination of the consequences for individual EU countries. On analysis, it soon became apparent that certain countries would be expected to implement emission reduction measures that were in the least cost-effective part of their own country's cost-effectiveness curve (i.e. well above the 'knee' on the national cost curves).

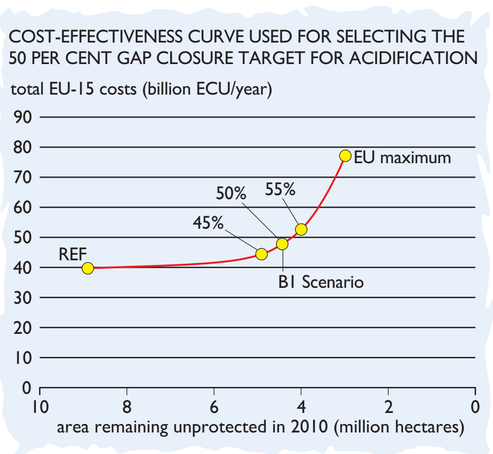


Figure 1
The EU-15 cost-effectiveness curve used by the European Commission as the basis for selecting the 50 per cent gap-closure target for acidification

CONCAWE has conducted an investigation into the consequences of no country being forced to implement measures in the least cost-effective part of its national cost curve. The aim was to provide further information and a sensitivity analysis beyond that which was provided by the Commission during the development of its proposed Acidification Strategy.

The International Institute of Applied Systems Analysis' (IIASA) Regional Air Pollution Information and Simulation (RAINS) model (Version 7.2) was used both to develop the Commission's Acidification Strategy and in this CONCAWE sensitivity analysis. Hence, the CONCAWE results can be compared directly with the RAINS results used in developing the original Acidification Strategy. However, there have been many changes to this model since Version 7.2 and these changes are likely to have a significant effect on any modelling results. This means that the results from the original Acidification Strategy work and this CONCAWE sensitivity analysis must necessarily be considered as indicative only.

MODELLING METHODOLOGY

Version 7.2 of the RAINS model was used, and specifically those files relating to the Commission Acidification Strategy's 50 per cent gap-closure scenario—the so-called 'B1 Scenario'.

It was first necessary to determine the 'knee' of the cost curves for each country. For many countries there is not a clear point of inflection, and choosing a point becomes rather subjective. However, for most countries, the cost curve starts to rise very steeply for abatement techniques that cost more than:

- 2000 ECU/tonne SO_2
- 2000 ECU/tonne NO_x
- 4000 ECU/tonne NH_3

The location of the 'knee' and ceiling is illustrated in Figure 2.

These cost-effectiveness ceilings were used as pseudo policy constraints in the model runs for the EU-15 countries, i.e. no EU-15 country would be expected to implement measures that were less cost-effective than the values used above. However, where an EU-15 country is already committed to implementing measures under the so-called REFerence Scenario[1] that are more expensive than the relevant value above, this additional commitment is used as the national ceiling in this analysis. Non-EU-15 countries were assumed not to implement any measures beyond those they are committed to under the REFerence Scenario.

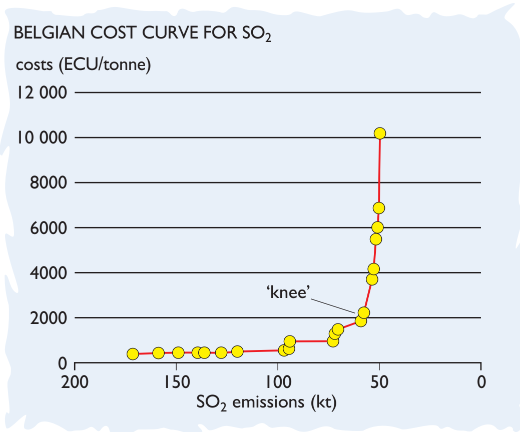


Figure 2
Relative cost-effectiveness of different measures to reduce SO_2 emissions, and the position of the 'knee' on the Belgian cost curve

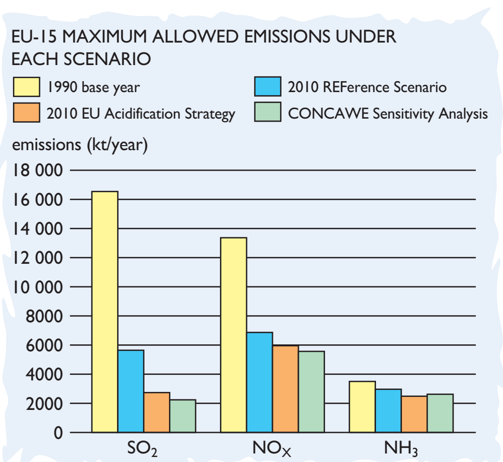
It should be noted that these new constraints posed in the CONCAWE sensitivity analysis mean that a strict 50 per cent gap closure target is infeasible in a very small number of the model's European grid squares (3 to 4 grids). Consequently, the target acid deposition levels in these squares had to be increased slightly above those used in the B1 Scenario analysis.

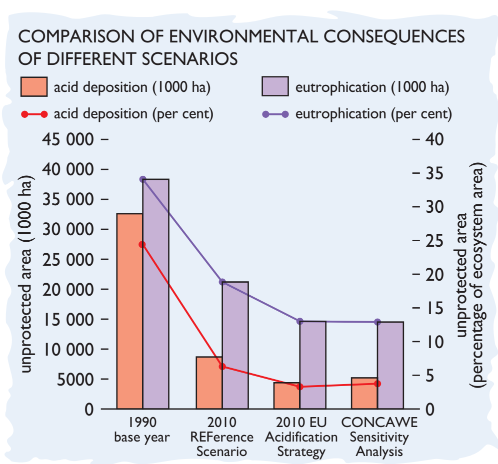
MODELLING RESULTS FOR THE EU-15

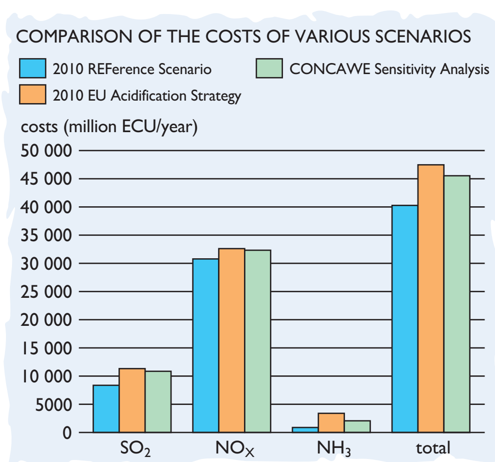
Comparing the results from the CONCAWE sensitivity analysis and the DG-XI B1 scenario, it can be seen that the CONCAWE sensitivity analysis would:

- require greater overall emission reductions (see Figure 3);
- achieve similar overall protection from acidification (0.6 per cent less area would be protected) (see Figure 4);
- achieve similar overall protection from eutrophication (0.1 per cent less area would be protected) (see Figure 4); and
- the overall costs in addition to the REFerence case are 27 per cent less (see Figure 5).

Figures 3, 4 and 5 (below, left to right) Modelling results from the CONCAWE Sensitivity Analysis and the DG-XI B1 scenario compared.







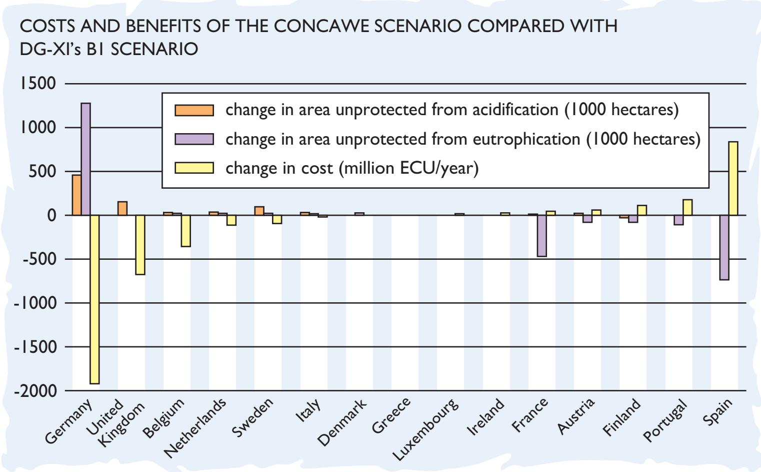


Figure 6
Costs and benefits of the CONCAWE scenario compared with DG-XI's B1 scenario

When the results of the CONCAWE sensitivity analysis results are compared with the Commission's proposal at the country level, it can be seen that there are substantial changes in the costs and benefits for certain countries. The changes are illustrated in Figure 6. Under the Commission's Acidification Strategy proposals Germany, Italy, The Netherlands and the UK would bear a large proportion of the EU total costs. Under the CONCAWE scenario the overall cost burden is more broadly shared. Comparing the environmental consequences, it is clear that the reduced costs for Germany (and its neighbours), would result in a greater area being left unprotected from acidification, particularly in Germany itself, the UK and Sweden, and from eutrophication, again particularly in Germany. The additional costs for France, Austria, Finland, Portugal and Spain are compensated for by an improved protection of ecosystems in those countries.

IMPLICATIONS FOR DECISION MAKERS

The analysis outlined above demonstrates that there are a number of ways in which the balance of costs versus benefits can be determined. Adherence to a strict 50 per cent gap closure target across the EU-15 means that very expensive measures would be introduced in some Member States. This degree of ambition and the rigidity of its application has been questioned by several countries and, at the request of the December 1997 Environment Council, the Commission is to consider alternative approaches to setting targets for reducing Acidification. Although the Commission is investigating different target setting approaches, it has indicated that it has no intention of relaxing its ambitions to combat acidification in its development of a National Emissions Ceilings Directive. This CONCAWE analysis indicates one way that the introduction of a little flexibility could substantially reduce costs without materially lowering the ambition level.

Up-to-date analysis is dependent upon the release of the most recent version of the RAINS model or on modelling runs being undertaken by IIASA themselves. Industry has pressed for release of the next version of the RAINS model so that it can explore the various policy setting options further. Unfortunately, there is every indication that the up-to-date model will not be released in time for important sensitivity analyses to be undertaken by industry or other interested parties. Indeed the Commission's current timetable is such that IIASA themselves will not be able to undertake the necessary sensitivity and uncertainty analyses to examine a wider range of options for setting mandatory national emission reductions under the proposed National Emissions Ceilings Directive.

It is important that the forthcoming National Emission Ceilings Directive, that will bring together measures to control acidification, tropospheric ozone and eutrophication, is realistic at the national, European and intercontinental levels. The emerging DG-XI proposal would require a significant percentage of the national gross domestic product (GDP) to be spent in certain countries and their economies may suffer unnecessarily if unreasonable emission reductions are imposed.

[1] *The REFerence Scenario from the IIASA 2nd Interim Report is the RAINS scenario for 2010 which takes into account the effects of existing and agreed legislation on emissions.*

Cost-effectiveness of marine vapour emissions control

CONCAWE updates its figures in the light of European and US experience.

BACKGROUND

The European Directive (94/63/EC) on the 'control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations', the so-called Stage-1 Directive, does not currently address controls of vapour emissions from ships. Stipulation of such controls was delayed, pending discussions within the International Maritime Organization (IMO) concerning international standardization and safety during the loading of ships. Article 9 of the Directive invites the Commission to come forward with proposals, where appropriate, for amendment of the Directive, including in particular the extension of the scope to include vapour control and recovery systems for loading installations and ships. The proposals for amendments are to coincide with the Commission's first report on the implementation of the Directive.

CONCAWE Report 92/52 reviewed costs and cost-effectiveness of installing vapour emission controls (VECs) for loading of gasoline into ships and barges. In that study the data were primarily based on project studies as only 2 barge loading VECs had been installed. CONCAWE has undertaken an update of the cost data taking account of both the experience gained with installed systems in the USA and Europe and new project studies. The study results are reported here.

SHORE-SIDE COSTS

Figure 1 shows the reported capital expenditure (Capex) for vapour emission control systems plotted against design capacity for 20 facilities.

The plot shows that costs vary widely for systems with similar design capacities—the costs of vapour emission control systems are very dependent on site-specific issues including:

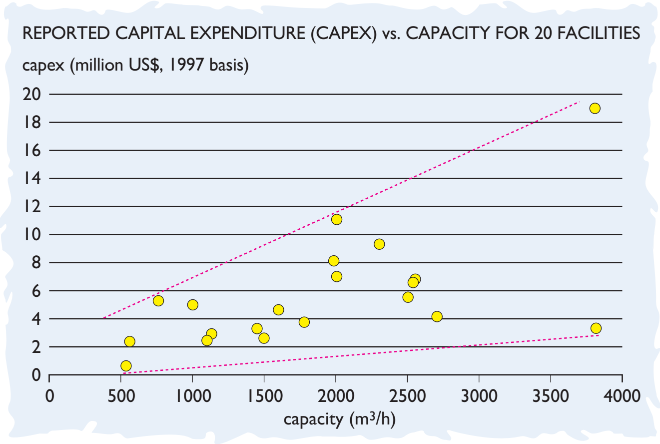


Figure 1
The costs to install vapour emission control systems vary widely, and are dependent on a variety of site-specific issues.

- the number of loading berths connected to the system;
- the distances between the berths and the shore line;
- the length of vapour line to the location of the emissions control facility;
- the need for blowers to assist vapour flows over long distances;
- the number and level of redundancy of measurement, alarm and safety systems; and
- whether additional gas is added to the vapour to reduce the risk of ignition propagation along the vapour collection lines.

SHIP-BOARD COSTS

In order for vapours to be collected and passed to a shore-side emission control system, sea-going vessels will need to have vapour collection pipework on board. The costs to fit this depends on tankers being equipped with closed loading and/or inert gas systems. The latter, for example, could be used as the vapour collection system during loading.

As identified in the aforementioned CONCAWE Report, the costs of modifying sea-going vessels vary considerably. Reported costs from both actual retrofits and project estimates compare well with the costs identified previously adjusted for inflation. These are:

- for a vessel without inert gas: US$275 000
- for a vessel with inert gas: US$130 000

From an analysis of the tanker data in the Lloyds Register, it is estimated that gasoline is transported in about 600 sea-going vessels of less than 40 000 tonnes dead weight in European waters. Of these, about 100 are assumed to have inert gas systems already fitted. Thus the total cost to retrofit these vessels will be of the order of US$151 million.

COST-EFFECTIVENESS

Cost-effectiveness is defined as the annual cost in US dollars required to achieve the annual reduction in emissions in tonnes. The overall cost-effectiveness of marine loading vapour emission controls is the sum of the cost-effectiveness of the investments for both the shore-side and on-board vessel equipment.

SHORE-SIDE INVESTMENT

The cost-effectiveness of a shore-side facility can be calculated from the emission reduction achievable, the annualized cost of the capital investment, and operating and maintenance costs. An annual capital charge (ACC) of 15 per cent has been used[1]. The operating and maintenance costs have been taken to be 5 per cent and 2 per cent of capital respectively. No allowance has been made for either tax incentives or for the untaxed benefit associated with the recovered vapours, because the majority of gasoline loaded into ships is duty free and the untaxed value of the recovered vapours is low.

[1] *Rather than the conventional annual capital charge (ACC) of 25% used by CONCAWE, an ACC of 15% has been used. This allows a comparison with Auto/Oil 1 costs since it is based on the AOP I net present value for a 7% discount rate. A standard Discounted Cash Flow calculation over a 10-year plant lifetime is linked to a construction phasing of 2 years, 15% in the first year and 85% in the second year.*

The uncontrolled emissions during loading have been calculated using an emission factor of 0.034 per cent by volume (derived from API Publication 2514A, 1987).

Figure 2 plots the cost of abatement (US$ per tonne) for the 20 reported shore-side facilities.

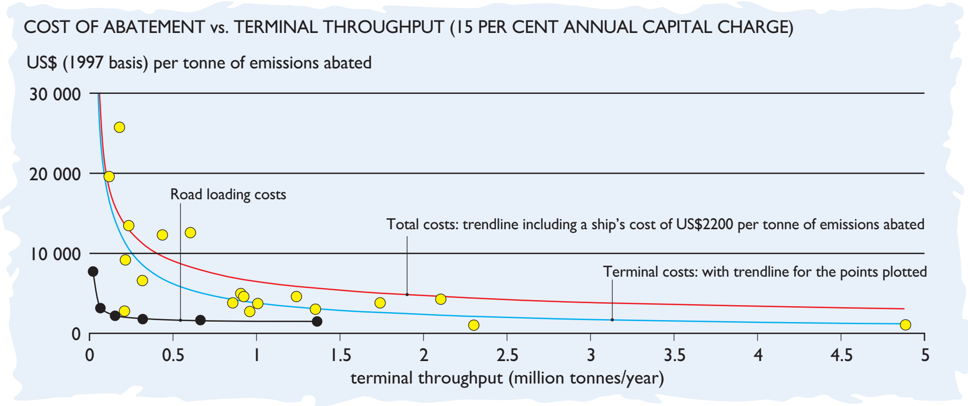


Figure 2
Cost of abatement vs. terminal throughput for 20 reported shoreside facilities (15 per cent ACC)

ON-BOARD VESSEL INVESTMENT

The overall cost-effectiveness of the total vessel on-board investments can be calculated from the total emission reduction achievable if all ships and terminals were equipped for vapour emission controls and the total vessel retrofit costs.

An annual capital charge of 15 per cent has been used. It has been assumed that there will be no additional on-board operating and maintenance costs.

Within Europe about 38 Mt/year gasoline is loaded onto sea-going vessels. Using the emission factor of 0.034 per cent vol. and a total ship retrofit cost of US$151 million gives a cost-effectiveness of the vessel on-board equipment of 2200 US$/tonne emissions abated.

TOTAL INVESTMENT

The cost-effectiveness of the total investment has been determined by summing the cost-effectiveness figure for the vessel on-board costs with that for the on-shore facility costs. Figure 2 shows the trend-line of the total costs of abatement plotted against terminal throughput.

For comparison, the average cost-effectiveness for Stage I vapour recovery on road loading and deliveries, including the cost of modifying the road tanker fleet, was determined in CONCAWE Report 90/52 to range from 1200 to 8200 US$/tonne with an average of 2400 US$/tonne (adjusted for inflation). The average cost data are included in Figure 2.

CONCLUSIONS

The costs of installing a vapour emissions control system for loading gasoline onto sea-going vessels vary significantly at sites with similar product loading rates because of site specific issues. Reported costs for sites with loading rates typical of a large refinery, range from 4 to 20 million US$.

It is estimated that about 600 sea-going vessels of less than 40 000 tonnes dead weight will require vapour emission collection systems installed to permit trading to terminals fitted with vapour emission control systems. The total retrofit cost is estimated at US$151 million.

The overall cost-effectiveness of vapour emission controls for the largest facility would be of the order of 3200 US$/tonne emissions abated and could exceed 25 000 US$/tonne as terminal throughput decreases. This compares with a range from 1200 to 8200 US$/tonne for road loading.

Automotive polycyclic aromatic hydrocarbons (PAH)

A CONCAWE literature study reveals the need for much more work; CONCAWE will contribute.

The International Agency for Research on Cancer has classified certain PAH as carcinogenic to animals and probably carcinogenic to humans. Evidence for the carcinogenicity of some PAH is equivocal; for others there is no evidence of carcinogenic potential, and there are many others that have not even been tested. There is no common definition for the term ‘polycyclic aromatic hydrocarbon’. While in some scientific disciplines PAH are understood to be individual polycyclic aromatic hydrocarbons, in other areas the same term is used to define the total of all di- and tri+ aromatic components determined in diesel fuel. Even in this area there is still some conflict, for example, the Swedish diesel fuel specification uses the term PAH to refer only to tri+ aromatics.

Due to the concern about potential health effects the European Commission will propose an Air Quality Standard for PAH under a Daughter Directive under the EU Air Quality Assessment and Management Directive. The last *CONCAWE Review* outlined the complexity of the Daughter Directive for suspended particulate matter (PM_{10}). The issue for PAH is also very complex with contributions to ambient PAH coming from a range of different emission sources. This again necessitates experts from various scientific disciplines and industries working together. In this context it is worth noting that recent studies in various locations have demonstrated that the levels of PAH in current ambient air are the lowest ever measured largely as a result of the reduced use of coal in domestic and other heating.

In order to understand the contribution from automotive vehicles emissions to ambient PAH, CONCAWE have conducted a comprehensive literature review of polycyclic aromatic hydrocarbons levels in automotive exhaust emissions and fuels. This report is soon to be published.

The following overview is based on the report of the literature study.

THE KEY TO RELIABLE DATA LIES IN REPRESENTATIVE SAMPLING AND THE ANALYTICAL APPROACH

PAH are currently unregulated pollutants in automotive exhaust emissions and there is no consensus on the major PAH to be analysed, although the 16 PAH listed by the EPA are the most commonly measured. There is also no standard analytical methodology available. The analytical situation is very complicated because a sample taken from the exhaust includes a wide range of individual compounds and complicated ‘clean-up’ procedures are needed to prevent interference in the analysis. The range of specific structures that the analytical techniques employed at different laboratories are capable of quantifying varies greatly. It is generally assumed by each research group that the species they identify are representative of polycyclic aromatic hydrocarbons as a whole.

PAH may be emitted to the atmosphere either in the vapour phase or associated with fine particles. Therefore, data on PAH exhaust are required on both vapour and particle phases using appropriate sampling procedures. However, the contribution made by the vapour phase PAH has largely been neglected.

During the study it became evident that the key to reliable data lies in representative sampling and the analytical approach employed. The majority of the references cited use different analytical systems and consequently direct comparison is not always easy.

PAH IN THE EXHAUST

There is a large quantity of literature available reporting on the measurement of automotive PAH emissions. The majority of the literature relates to diesel emissions and predominantly to PAH in particulate. Vapour phase PAH emissions are addressed in fewer references and there is also much less information relating to gasoline PAH emissions. The nature of gasoline emissions (i.e. predominantly vapour), and the collection systems used, mean that results given are closer to the 'total' PAH emitted.

Surprisingly, there are few authors who attempt to correlate fuel composition/PAH levels with those measured in the exhaust or, indeed, who even include the measurement of PAH in the test fuels used.

Of particular importance is the fact that total hydrocarbon (HC) emissions (both vapour phase and particulate borne) are very low from modern gasoline and diesel engines. Furthermore, targeted PAH species form only a small (and not well determined) fraction of the particulate borne HC, and an even smaller (and even less well determined) fraction of the vapour phase HC.

Due to the wide range of test programme configurations reported (engine/vehicle type, driving cycle, sampling and analytical procedures) it is difficult to define maximum and minimum values of PAH in exhaust.

MECHANISMS OF FORMATION OF EXHAUST PAH ARE COMPLEX; FUEL PAH IS ONE CONTRIBUTOR

Several routes of formation are involved in the generation of exhaust PAH emissions, and individual mechanisms can contribute to a greater or lesser extent (Figure 1). The fraction of the fuel PAH which survives combustion is influenced by engine design, test cycle and the compatibility of fuel and engine. Other exhaust PAH can be created from non-PAH fuel components by pyrosynthesis which can be related to the amount of soot in the exhaust and can be a substantial fraction. PAH present from either route may also undergo further modifications thus making it difficult to interpret which formation route is the dominant one. The lubricating oil may also contribute to the exhaust PAH from PAH which have built up in the oil during the combustion process. Further complications in relating PAH to its source and to obtain repeatable results may come from the exhaust sampling system which can also act as a sink or source for PAH. The major mechanisms for PAH formation in the exhaust are shown in Figure 1. Unfortunately much of the published literature does not provide information in such a form to enable interpretation of the findings.

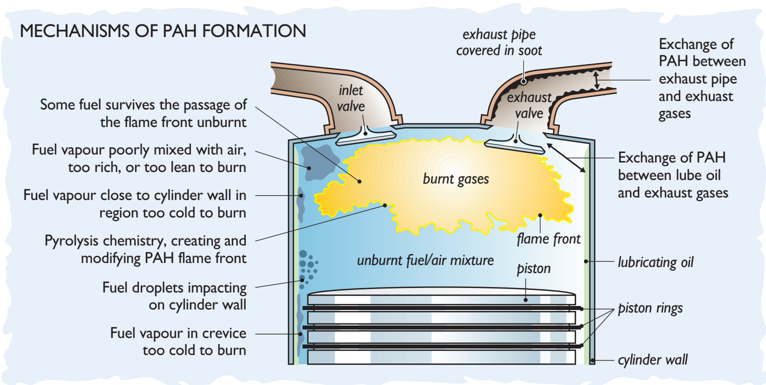
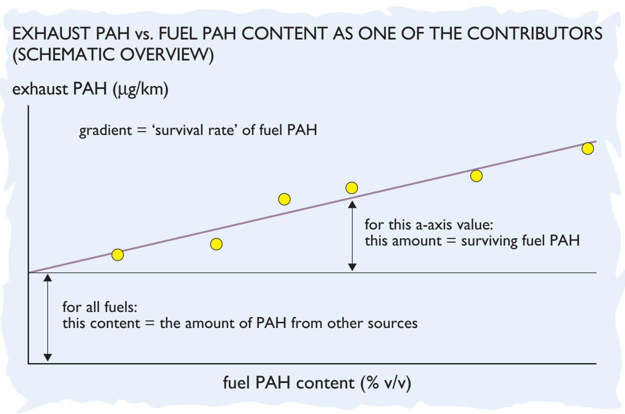


Figure 1
Several routes of formation are involved in the generation of exhaust PAH emissions.

PAH IN THE FUEL

Figure 2
Exhaust PAH versus fuel PAH content as one of the contributors (schematic overview)



CONCAWE attempted to summarize (from the limited data reported on commercial type fuels) the individual PAH levels most commonly determined in gasoline and diesel fuel. However, values may not strictly be comparable since different analytical methods have been used across the different references. In addition the chemical composition of a fuel depends on various factors (e.g. refinery configuration, blending streams, crude oil sources), and historical data are therefore unlikely to reflect current or future PAH content in automotive fuels. With regard to diesel fuel conflicting terms are used across the literature when describing 'PAH' in the fuel as outlined in the introduction.

The use of alternatives to conventional gasoline or diesel fuel is finding a growing niche market. These generally appear to give lower PAH emissions than traditional fuels. However, PAH emissions are still detected in exhaust emissions despite the fact that most of the fuels do not contain any aromatic compounds, thus providing independent evidence for the pyrosynthetic route.

AFTER-TREATMENT IS HIGHLY EFFECTIVE IN DECREASING PAH EMISSIONS

PAH emissions from automotive sources are highly variable and are dependent on a number of factors, including fuel composition. However, published data, though limited in their scope, indicate unequivocally that after-treatment systems are a highly effective means to substantially decrease PAH emissions, with diesel after-treatment devices showing some greater variation.

CONCLUSIONS

PAH form only a small part of the fuel, particularly in the case of gasoline. Total HC emissions are very low from modern engines and the scatter in measuring exhaust PAH levels is large. Therefore, well-designed test programmes are required. To ensure comparable results, the PAH to be analysed need careful definition, and a standard analytical method is required.

The recent report by CONCAWE has allowed potential future work to be identified and defined. Whilst for gasoline, it would appear that there is sufficient literature to understand the nature of current vehicle PAH emissions, more work is needed for diesel, both light- and heavy-duty. Published results on diesel are less conclusive and a wider scoping programme needs to be carried out to gain an accurate picture of the total PAH emissions and the extent of their relationship with fuel PAH content.

CONCAWE IS ACTIVE

Following the literature survey, CONCAWE has become involved in practical work to address some of the reported uncertainties. In preparation of a test programme, Ricardo Consulting Engineers and CONCAWE have conducted work in a cooperative research programme to develop a technique applicable to the simultaneous collection and measurement of both vapour phase and particulate bound PAH in exhaust emissions (SAE paper 982727).

A CONCAWE report which reviews data forming the basis for the establishment of an Air Quality Standard (focusing on inhalation carcinogenicity) is also under preparation.

The hazards of static electricity

Static electricity has been known for many years to be able to ignite petroleum vapours. Nevertheless, accidents continue to happen. Why is this?

Static electricity incidents have occurred in recent years which have highlighted concerns about explosion or fire while transferring vehicle fuels. These may indicate that changes taking place threaten the existing precautions for controlling these hazards.

It is a well-known phenomenon that if two materials are rubbed together, static electricity is generated and electric sparks can be produced. Common examples are walking across a nylon carpet and then touching a metal surface such as a hand-rail when an alarming (but harmless) shock can be felt. Also, removing nylon clothing in the dark can generate an impressive display of sparks. What is perhaps less well known (outside industry) is that the same phenomenon can occur with liquids, including gasoline, kerosine and diesel, which are poor conductors of electricity. Static discharges (e.g. lightning) can also be generated by water drops passing through the air. Although much smaller voltages than lightning are developed, water washing (and indeed fire-fighting sprays) can generate enough charge to ignite flammable liquids.

A build-up of static charge arises when low conductivity liquids are poured or pumped from one container to another. If precautions are not taken, then sufficient electrical charge can build up to cause a spark that can have enough energy to ignite a flammable vapour. This phenomenon was first observed in the oil industry many years ago and if no precautions were taken, fires would be extremely common, rather than the rare events that they are.

To prevent such fires, a number of precautions have been developed over the years. These include mechanical, procedural or chemical measures. For example, a key mechanical measure is to electrically bond all metal containers, pipework etc. to each other and to earth. Charged conductors cause a high spark risk. Procedural measures include instructing the operator to earth his road vehicle before filling, and to control fuel pumping rates to limit charge generation. Good design can help enforce procedural controls through automatic earthing or electrical interlocks. A further possibility is to modify the fuel itself by adding chemicals to increase its conductivity.

Engineering and procedures have been formalized in Codes of Practice issued by individual companies and by various groups such as professional and national bodies. It is essential that such Codes are kept under review as the original assumptions made when they were written may no longer apply due to changes in equipment or fuel properties.

A recent series of incidents occurred when road tankers were being loaded with diesel fuel. It has been recognized for a long time that this activity is more hazardous if the vehicle has previously contained gasoline. When filling starts, the gasoline vapour is too rich to be ignited, but as the vehicle fills with diesel, the hydrocarbon vapour moves through the explosive range. If a spark occurs at this point, an explosion is possible. This procedure is called switch loading and is considered a normal event provided that all the proper precautions have been taken. It had been thought that this was the case with these incidents so what went wrong?

At least two factors may be involved. The first relates to the design of road tankers which has changed in recent years to allow recovery of the hydrocarbon vapours so that they are not emitted to the environment. A result of this is that the vapour spaces of the various tanks in the vehicle are connected. It is thus more difficult to predict when a hazardous atmosphere may be present. Secondly, a number of these incidents involved a product known as 'City Diesel'. This product is very highly refined to remove virtually all of the sulphur and other trace compounds containing oxygen or nitrogen which contribute to the conductivity of hydrocarbon fuels. Consequently, the electrical conductivity is generally lower than the grades of diesel fuel previously marketed. This lower conductivity increases static charge accumulation and, hence, the risk of sparking. Research into the causes of these incidents found that other grades of diesel also can have lower conductivities than used to be the case, due to more intensive refining and better control of the distribution system.

Another series of fires was of more concern to the immediate consumer as they involved fires in car fuel tanks during refuelling in a number of countries. Fortunately, most of these were not serious and in most cases only led to minor damage.

When cars fill up at a service station, the pump is earthed and the filling hose is made of conductive material and electrically bonded to the metal nozzle. Electrical continuity is normally established by metal-to-metal contact between the car and the filling nozzle but this depends on there being a conducting path between the filler pipe and the rest of the car. Finally, the car itself is earthed through the tyres which contain enough carbon to have an adequate conductivity. This last factor is important as the car can be charged to a high voltage during its journey.

Failure of any of these connections could lead to a static discharge, but fires are normally very rare. Upon investigation, many of the incidents involved two particular models of cars where there was inadequate electrical bonding between the filler pipe and the rest of the car. Repair of accident damage using non-conducting filler gave the same result in some cases. In one series of incidents, the main cause seemed to be very dry weather which meant that the conductivity of the ground was too low to allow the charge to leak away from the car. This may have been made worse by the impermeable lining often installed in service stations to prevent oil pollution of the ground.

A variety of other factors were found to be involved in other incidents. Some tyres used silica rather than carbon, hence reducing their conductivity. Although not shown to be a factor in these incidents, sampling of current grades of gasoline found that, like diesel, the conductivity of gasoline can be much lower than used to be the norm.

During the research into these incidents, it was shown that electrical discharges can actually occur inside the car filler system. These did not start any fires, firstly because the energy was too low, but more importantly because the vapour inside the tank is too rich to support combustion. There are demands to lower the vapour pressure of gasoline to reduce VOC emissions. If this is taken too far, then under some conditions, the vapour in a car fuel tank could be explosive with possibly catastrophic results.

A common feature in many of these incidents was that changes to fuel specifications, vehicle design and service station construction standards, many of which were implemented for environmental reasons, could have been contributory factors. The message for the oil industry is that change, for whatever reason, has to be managed positively. The message for regulators is that when mandating such changes, all the possible impacts have to be thought through, and this can only be done through consultation with all interested parties.

CONCAWE pipeline seminar

More than one hundred pipeline experts met in Brussels in April to share experience on the safe and environmentally friendly operation of oil pipelines.

Every four years, CONCAWE organizes a seminar for pipeline operators in Europe to exchange experience on the safe operation of pipelines. These seminars have always been very successful and the one held in April 1998 was no exception with more than one hundred delegates attending from all over Europe. The timing of this seminar was opportune in that it coincided with the Commission of the EU developing proposals for an instrument on the control of major accident hazards from pipelines. The delegates were fortunate in receiving an after dinner talk from a Commission spokesman on this proposal. Whilst they may not have agreed with the need for such a Directive, they found the talk interesting and informative.

The overall theme of the seminar—pipeline performance improvement—was similar to previous ones. In all, there were 13 separate papers covering a wide range of topics. The first session looked at past performance. As in previous years, the first paper was on the CONCAWE Pipeline Incident Statistics. These have now been collected for more than 25 years and an overview of these has now been published as CONCAWE report No. 2/98. This paper was followed by a series of papers on stress corrosion cracking which had caused pipeline failure. These covered not so much the incidents themselves but the methods which have been developed to detect such cracks with intelligence pigs and to repair them before failure occurs.

The second session concentrated on procedural and legislative issues rather than technology. The first paper was on the ways to avoid damage to pipelines by third parties—an important topic as it is one of the main causes of leaks from pipelines. This was followed by papers on developments in European pipeline legislation and international standards, and subsequently by one on pipeline integrity management—again very topical as the expected pipeline directive is likely to require the use of such systems. There was also a presentation on geographical information systems, an important tool these days for recording information about the pipeline and the surrounding area. Finally, there was an example of how the active management of pipelines could identify weak spots in pipeline systems and repair them before serious leaks could arise.

The final session looked at a range of topics and included a talk and film on the actions that one Russian pipeline company (Transneft) is taking to upgrade and safeguard one of the crude oil pipelines to the West. This showed a high level of technology and achievement. There was also a paper on pipeline abandonment. Pipelines eventually come to the end of their economic life, not necessarily because they are too old, or corroded beyond repair, but frequently because the reason for which they were built no longer exists, perhaps because the refinery they fed has closed. Abandonment is therefore always included in a management system, even if the prospect of it is remote. Finally, delegates were given a stimulating talk on future pipeline technology and an update on the latest developments with intelligence pigs and leak detection. Such techniques are required to ensure that the industry can retain and improve its record of pipeline transport as one of the safest ways to transport oil in bulk.

Less oil in refinery effluents

A CONCAWE survey of European refineries has shown big reductions in the amount of oil discharged.

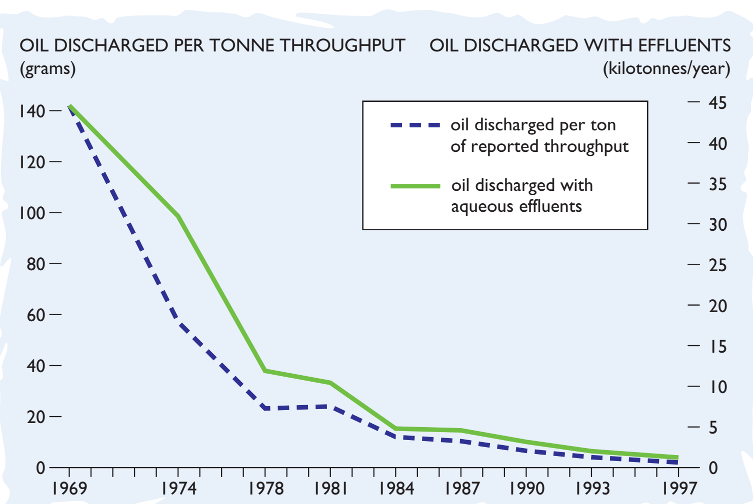
CONCAWE first started collecting data on refinery effluents as long ago as 1969. In those days, environmental awareness was in its infancy and this was reflected in the quantity of oil discharged in these effluents, which amounted to 44 000 tonnes from 80 refineries. This survey has been repeated at three- to five-year intervals since then and the most recent survey has just been completed for the year 1997.

The quantity of oil discharged has decreased in every survey and this time was no exception. In 1997, it had fallen to 1455 tonnes from 104 refineries which represents a 43 per cent decrease over the last survey in 1993 (95 refineries). If only those refineries which reported in both surveys are considered, the decrease was even bigger at 50 per cent. If we compare the 1997 data with that from 1969, the reduction in oil discharged is a massive 97.4 per cent.

The European refinery population has changed considerably since 1969 and so too has the amount of oil processed. To take account of these changes, the ratio of oil discharged to oil processed has been calculated. In 1997, this ratio was 1.87 tonnes oil discharged per million tonnes oil processed (i.e. 1.87 ppm). This also represented a 43 per cent reduction since 1997 and a 98.7 per cent reduction since 1969.

The reductions in discharges over the last four years have arisen partly from small improvements at a large number of refineries in both preventing oil entering the effluent in the first place (source control) and in the treatment of the effluent. There have also been a number of cases where new effluent treatment systems have been installed leading to large reductions. One quarter of all refineries reported that they had improved their treatment systems and, as a result, 88 per cent of all refineries treat their effluent with some sort of biological treatment which is normally the most advanced type of treatment used.

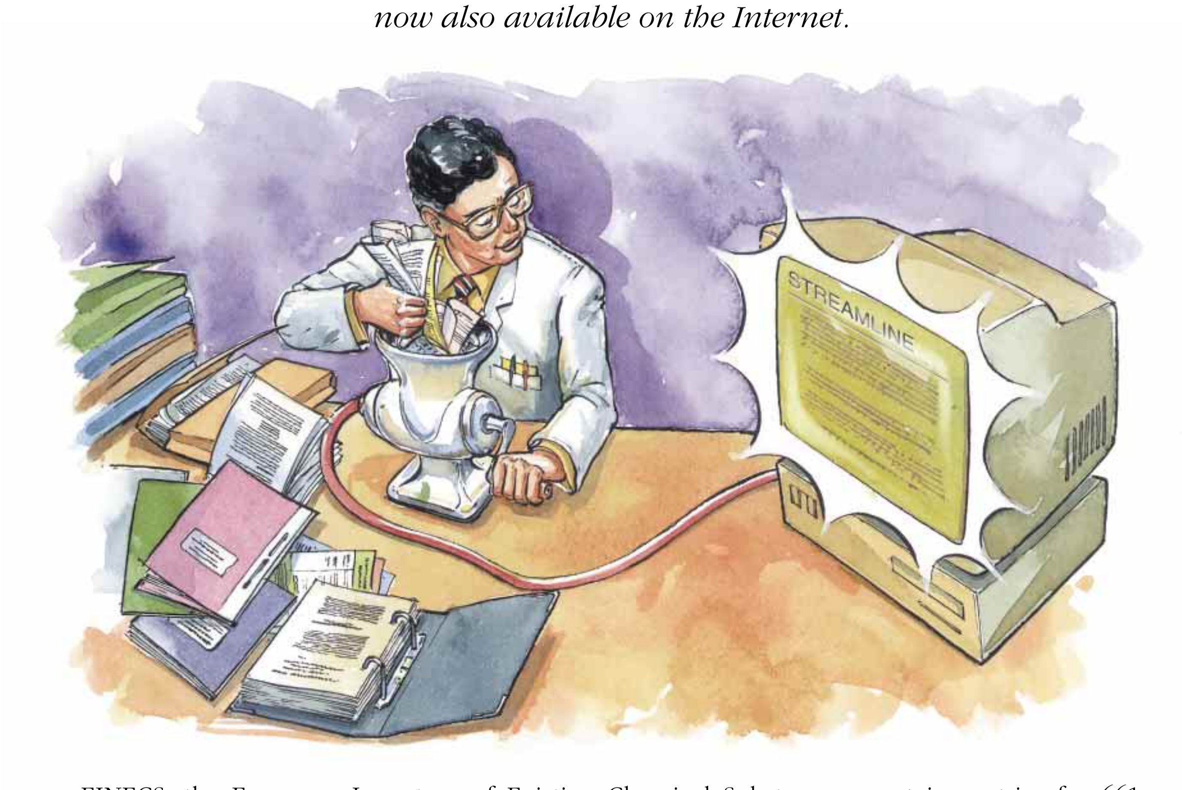
Figure 1
Trends in oil discharged, 1969–97



For recent surveys, OSPARCOM (the intergovernmental body covering the North Sea and Atlantic Ocean) has carried out its survey at the same time and using the same questionnaire as CONCAWE. This time, OSPARCOM asked CONCAWE to collect all the data rather than asking each member state. The area involved contains 66 refineries and, despite being given a very tight time-scale, CONCAWE delivered all the data for these refineries on schedule.

Reclassification of petroleum substances

New data and new hazard criteria necessitate a report update, now also available on the Internet.



EINECS, the European Inventory of Existing Chemical Substances, contains entries for 661 petroleum substances, all of which have to be classified and labelled under the Dangerous Substances Directive (DSD) for all the hazards that they present. Such classification has also to be mirrored in the information conveyed in the safety data sheets that must be made available for each of these substances.

In the period 1992–94, the Technical Progress Committee (TPC) Working Party considered the classification of petroleum substances under the DSD, but concentrated almost entirely on the carcinogenic hazard from these products. On a pragmatic basis, the TPC Working Party agreed with CONCAWE's suggestion that petroleum substances should be looked at on a group basis and to this end, they were allocated to 35 groups. These groups are listed in a previous *CONCAWE Review* article from April 1993 (Volume 2, Number 1).

THE 21ST ADAPTATION TO TECHNICAL PROGRESS (ATP)

The culmination of the work of the TPC Working Party was the publication of Directive 94/69/EC, the 21st ATP of the DSD. Annex I of this Directive contains entries for more than 500 petroleum substances constituting 23 groups. However, the classifications afforded to these entries were limited to the health hazards of carcinogenicity and aspiration. Further, at this time, the classification for aspiration hazard was not satisfactory in that no criteria were assigned and this hazard was only assigned to certain defined substances consisting of low boiling point naphthas and kerosines.

CONCAWE REPORT NO. 95/59

The 21st ATP of the Dangerous Substances Directive[1] requires CONCAWE companies to self-classify their substances for flammability, environmental hazard and other health hazards. Recommendations on the regulatory and self-regulatory requirements were provided by CONCAWE in the form of Report No. 95/59 *(The Classification and Labelling of Petroleum Substances according to the EU Dangerous Substances Directive).*

CONCAWE REPORT NO. 98/54

Since 1995, further data on the environmental hazard presented by petroleum substances has become available from aquatic toxicity studies commissioned by CONCAWE and its member companies. This has necessitated a revision of the advice contained in Report No. 95/59. Further, Directive 96/54/EC, the 22nd ATP to the DSD has been published and this has included criteria against which to decide whether substances pose an aspiration hazard (see *CONCAWE Review,* October 1996, Volume 5, Number 2). Additionally, a number of requirements for labelling of petroleum substances have arisen under Amendments and ATPs to the Restrictions on Marketing and Use Directive (76/769/EEC). The combination of these legislative changes and the new environmental data has resulted in CONCAWE producing an updated version of Report No. 95/59 and this is now available as Report No. 98/54 *(Classification and Labelling of Petroleum Substances according to the EU Dangerous Substances Directive (Revision 1)).*

This report is largely a reference work document and it has been included on the CONCAWE Internet web site (http://www.concawe.be). The information that it contains is principally intended for regulatory personnel in companies, who are concerned with national legislation relating to the classification and labelling and the provision of safety data sheets for petroleum substances.

STREAMLINE DATABASE

Although the new report (98/54) is a very useful reference source it was decided to further assist prospective users by making it available as a searchable database for installation on a personal computer.

The database, known as STREAMLINE has been created in Microsoft® Access 97 and includes all the information that is given in the new report. However, to make it easier to find information for a specific substance, the database is searchable by CAS number, EINECS number, or EU Index number. For each substance, information is provided on the classification and labelling requirements and an example label is also shown.

STREAMLINE is available, via Internet on the CONCAWE home page (http://www.concawe.be).

The database can be downloaded as a self-executable file and requires Microsoft Access 97 to be installed on the PC. A runtime version of STREAMLINE, not requiring Access, is also available on the website.

[1] *Commission Directive 94/69/EC published in Official Journal L351 31.12.94*

CONCAWE news

SECRETARIAT

We would like to welcome Bo Dmytrasz and Jan Urbanus, both from Texaco, as new Technical Coordinators on the CONCAWE team. Bo has a broad expertise in product stewardship and takes over the petroleum product work from Barry Simpson and Don Short. Jan succeeds Barry Simpson in the field of health. We wish to thank Barry and Don for all their contributions to the work of CONCAWE and wish them well in future.

A CONCAWE Intranet is being developed with the purpose of improving communication with, and between, the people active in CONCAWE.

ERRATUM

In the article 'The cost-effectiveness of controls on sulphur emissions from ships' on page 10 of *CONCAWE Review* Volume 7, Number 1 (April 1998) the cost for removing sulphur from a limited quantity of bunker fuel for selective use should have read 1.5 ECU ('97)/kg SO_2 abated, i.e. 3 ECU/kg sulphur removed. The corrected copy is shown below.

Updated CONCAWE cost estimates for limited volume of low sulphur bunker fuel

Bunker sulphur content	*Additional cost of producing low sulphur bunker fuel compared with current high sulphur bunker fuels (1997 ECU/tonne)*	*Cost of SO_2 removed (1997 ECU/kg of SO_2)*
2% mass	35–50	1.5
1.5% mass	45–70	1.5
1.0% mass	55–85	1.5

N.B. Cost figures are based upon the supply of up to 8 million tonnes per annum, for selective use of low sulphur bunker fuel. The original data is based on a bunker sulphur content of 3.4% mass; these costs (when expressed per kg SO_2 removed) also apply at the current average of around 3% mass. The 1991 data have been increased by 15% to update them to 1997 costs (this represents the low end of the inflation figures given for a number of countries in Europe).

SECRETARIAT STAFF

Secretariat staff		Areas of responsibility
Secretary-General	Jochen Brandt	
Technical Coordinators	Suzie Baverstock	Air quality
	Henk Schipper	Air quality
	Bo Dmytrasz	Petroleum products
	Peter Heinze	Automotive emissions
	Kees van Leeuwen	Publications and refining planning
	Eric Martin	Safety management, oil pipelines, water and soil protection, and waste management
	Barry Simpson/ Jan Urbanus	Health
Administration	Martien Sijbrandij	
Secretaries	Laurence Evrard	
	Sandrine Faucq	
	Elfriede Geuns	
	Annemie Hermans	Library
	Barbara Salter	

CONCAWE PUBLICATIONS, 1997 TO DATE

General circulation (yellow cover) reports:

1/97	Petroleum products—first aid emergency and medical advice[1]
2/97	European oil industry guideline for risk-based assessment of contaminated sites
3/97	Task risk assessment
5/97	Vehicle emissions standards and fuel qualities—part 1
6/97	Vehicle emissions standards and fuel qualities—part 2
7/97	Performance of cross-country pipelines in Western Europe
8/97	Catalogue of CONCAWE reports
1/98	Methods of prevention, detection and control of spillages in European oil pipelines
2/98	Western European cross-country oil pipelines—25-year performance statistics
3/98	Sulphur dioxide emissions from oil refineries and combustion of oil products in western Europe and Hungary (1995)

Special interest (white cover) reports

97/51	Scientific basis for an air quality standard for carbon monoxide
97/52	Exposure profile: gasoline
97/53	Proposed EU 2000 gasoline volatility specifications
97/54	The health hazards and exposures associated with gasoline containing MTBE
97/55	A joint petroleum petrochemical barge inspection questionnaire
97/56	Catalogue of CONCAWE special interest reports
98/51	A study of the number, size and mass of exhaust particles emitted from European diesel and gasoline vehicles under steady-state and European driving cycle conditions
98/52	Exposure profile: crude oil
98/53	Pilot study to investigate airborne benzene levels in service station kiosks
98/54	Classification and labelling of petroleum substances according to the EU Dangerous Substances Directive (Revision 1)

Product dossiers

95/107	Gas oils (diesel fuels/heating oils)
97/108	Lubricating oil base stocks
98/109	Heavy fuel oils

[1] *This report is also available on http://www.concawe.be*

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